

This listing of claims will replace all prior versions, and listings, of claims in the application:

1 Claim 1 (currently amended): A method for use in a  
2 multi-stage switch including  
3 - a number,  $k \times n$ , of output ports,  
4 - a plurality of central modules, and  
5 - a plurality of input modules, each including  $k$   
6 groups of  $n$  virtual output queues and outgoing links  
7 coupled with each of the plurality of central modules,  
8 for scheduling a ~~the~~ dispatch of cells stored in the  
9 virtual output queues, the method comprising:  
10 a) matching a non-empty virtual output queue of an  
11 input module with an outgoing link in the input  
12 module, wherein the outgoing link has an associated  
13 master arbitration operation for selecting one of the  
14  $k$  groups of  $n$  virtual output queues; and  
15 b) matching the outgoing link with an outgoing link  
16 of one of the central modules.

1 Claim 2 (original): The method of claim 1 wherein the act  
2 of matching a non-empty virtual output queue of an input  
3 module with an outgoing link in the input module includes:  
4 i) sending, on behalf of each non-empty virtual  
5 output queue, a request to slave arbiters, each  
6 of the slave arbiters being associated with one  
7 of each of the outgoing links of the input  
8 module, and each of the slave arbiters being  
9 associated with the group of virtual output  
10 queues to which the non-empty virtual output  
11 queue belongs;

12           ii) sending, on behalf of each group of virtual  
13           output queues to which a non-empty virtual output  
14           queue belongs, a request to master arbiters, each  
15           of the master arbiters being associated with one  
16           of each of the outgoing links of the input  
17           module;  
18           iii) selecting, with each of the master  
19           arbiters, a virtual output queue group having at  
20           least one non-empty virtual output queue, from  
21           among one or more virtual output queue groups  
22           that sent a request;  
23           iv) selecting, with each of the slave arbiters,  
24           a non-empty virtual output queue, belonging to  
25           its associated group, from among one or more  
26           virtual output queues that sent a request; and  
27           v) selecting, with the arbiter of the each of  
28           the selected non-empty virtual output queues of  
29           each of the selected virtual output queue groups,  
30           an outgoing link from among the one or more  
31           candidate outgoing links, each of the one or more  
32           candidate outgoing links being associated with a  
33           master arbiter that selected the virtual output  
34           queue group and a slave arbiter that selected the  
35           non-empty virtual output queue.

1   Claim 3 (original): The method of claim 2 wherein the act  
2   of matching a non-empty virtual output queue of an input  
3   module with an outgoing link in the input module occurs  
4   within one cell time slot.

1   Claim 4 (original): The method of claim 2 wherein an act  
2   of selecting, with a master arbiter, a virtual output queue

3 group having at least one non-empty virtual output queue,  
4 is done in accordance with a round robin discipline.

1 Claim 5 (original): The method of claim 2 wherein an act  
2 of selecting, with a slave arbiter, a non-empty virtual  
3 output queue, belonging to its associated group, is done in  
4 accordance with a round robin discipline.

1 Claim 6 (original): The method of claim 2 wherein the act  
2 of selecting, with the arbiter of the each of the selected  
3 non-empty virtual output queues of each of the selected  
4 virtual output queue groups, an outgoing link from among  
5 the one or more candidate outgoing links, is done in  
6 accordance with a round robin discipline.

1 Claim 7 (original): The method of claim 2 wherein the acts  
2 of  
3 i) sending, on behalf of each non-empty virtual  
4 output queue, a request to slave arbiters, each  
5 of the slave arbiters being associated with one  
6 of each of the outgoing links of the input  
7 module, and each of the slave arbiters being  
8 associated with the group of virtual output  
9 queues to which the non-empty virtual output  
10 queue belongs;  
11 ii) sending, on behalf of each group of virtual  
12 output queues to which a non-empty virtual output  
13 queue belongs, a request to master arbiters, each  
14 of the master arbiters being associated with one  
15 of each of the outgoing links of the input  
16 module;

17           iii) selecting, with each of the master  
18 arbiters, a virtual output queue group having at  
19 least one non-empty virtual output queue, from  
20 among one or more virtual output queue groups  
21 that sent a request;  
22           iv) selecting, with each of the slave arbiters,  
23 a non-empty virtual output queue, belonging to  
24 its associated group, from among one or more  
25 virtual output queues that sent a request; and  
26           v) selecting, with the arbiter of the each of  
27 the selected non-empty virtual output queues of  
28 each of the selected virtual output queue groups,  
29 an outgoing link from among the one or more  
30 candidate outgoing links, each of the one or more  
31 candidate outgoing links being associated with a  
32 master arbiter that selected the virtual output  
33 queue group and a slave arbiter that selected the  
34 non-empty virtual output queue,  
35 are performed at least twice within one cell time slot.

1   Claim 8 (original): The method of claim 1 wherein the act  
2 of matching the outgoing link of the input module with an  
3 outgoing link of one of the central modules includes:  
4       i) sending a request for the outgoing link of the input  
5 module to an arbiter for each of the outgoing links of  
6 the central modules that leads towards an output port  
7 associated with the virtual output queue matched with the  
8 outgoing link of the input module; and  
9       ii) selecting with the arbiter of each of the outgoing  
10 links of the central modules, an outgoing link of an  
11 input module from among those that sent a request.

1 Claim 9 (original): The method of claim 8 wherein the act  
2 of selecting with the arbiter of each of the outgoing links  
3 of the central module, an outgoing link of the input module  
4 that broadcast a request, is done based on a round robin  
5 discipline.

1 Claim 10 (original): A method for use in a multi-stage  
2 switch including

3 - a number,  $k \times n$ , of output ports,  
4 - a plurality of central modules, and  
5 - a plurality of input modules, each including  $k$   
6 groups of  $n$  virtual output queues and outgoing links  
7 coupled with each of the plurality of central modules,  
8 for matching a non-empty virtual output queue of an input  
9 module with an outgoing link in the input module, the

10 method comprising:

11 a) sending, on behalf of each non-empty virtual  
12 output queue, a request to slave arbiters, each of the  
13 slave arbiters being associated with one of each of  
14 the outgoing links of the input module, and each of  
15 the slave arbiters being associated with the group of  
16 virtual output queues to which the non-empty virtual  
17 output queue belongs;

18 b) sending, on behalf of each group of virtual output  
19 queues to which a non-empty virtual output queue  
20 belongs, a request to master arbiters, each of the  
21 master arbiters being associated with one of each of  
22 the outgoing links of the input module;

23 c) selecting, with each of the master arbiters, a  
24 virtual output queue group having at least one  
25 non-empty virtual output queue, from among one or more  
26 virtual output queue groups that sent a request;

27       d) selecting, with each of the slave arbiters, a  
28       non-empty virtual output queue, belonging to its  
29       associated group, from among one or more virtual  
30       output queues that sent a request; and  
31       e) selecting, with the arbiter of the each of the  
32       selected non-empty virtual output queues of each of  
33       the selected virtual output queue groups, an outgoing  
34       link from among the one or more candidate outgoing  
35       links, each of the one or more candidate outgoing  
36       links being associated with a master arbiter that  
37       selected the virtual output queue group and a slave  
38       arbiter that selected the non-empty virtual output  
39       queue.

1   Claim 11 (original): The method of claim 10 wherein the  
2   act of matching a non-empty virtual output queue of an  
3   input module with an outgoing link in the input module  
4   occurs within one cell time slot.

1   Claim 12 (original): The method of claim 10 wherein an act  
2   of selecting, with a master arbiter, a virtual output queue  
3   group having at least one non-empty virtual output queue,  
4   is done in accordance with a round robin discipline.

1   Claim 13 (original): The method of claim 10 wherein an act  
2   of selecting, with a slave arbiter, a non-empty virtual  
3   output queue, belonging to its associated group, is done in  
4   accordance with a round robin discipline.

1   Claim 14 (original): The method of claim 10 wherein the  
2   act of selecting, with the arbiter of the each of the  
3   selected non-empty virtual output queues of each of the

4 selected virtual output queue groups, an outgoing link from  
5 among the one or more candidate outgoing links, is done in  
6 accordance with a round robin discipline.

1 Claim 15 (original): The method of claim 10 wherein the  
2 acts of

- 3 a) sending, on behalf of each non-empty virtual  
4 output queue, a request to slave arbiters, each of the  
5 slave arbiters being associated with one of each of  
6 the outgoing links of the input module, and each of  
7 the slave arbiters being associated with the group of  
8 virtual output queues to which the non-empty virtual  
9 output queue belongs;
- 10 b) sending, on behalf of each group of virtual output  
11 queues to which a non-empty virtual output queue  
12 belongs, a request to master arbiters, each of the  
13 master arbiters being associated with one of each of  
14 the outgoing links of the input module;
- 15 c) selecting, with each of the master arbiters, a  
16 virtual output queue group having at least one  
17 non-empty virtual output queue, from among one or more  
18 virtual output queue groups that sent a request;
- 19 d) selecting, with each of the slave arbiters, a  
20 non-empty virtual output queue, belonging to its  
21 associated group, from among one or more virtual  
22 output queues that sent a request; and
- 23 e) selecting, with the arbiter of the each of the  
24 selected non-empty virtual output queues of each of  
25 the selected virtual output queue groups, an outgoing  
26 link from among the one or more candidate outgoing  
27 links, each of the one or more candidate outgoing

28 links being associated with a master arbiter that  
29 selected the virtual output queue group and a slave  
30 arbiter that selected the non-empty virtual output  
31 queue,  
32 are performed at least twice within one cell time slot.

1 Claim 16 (original): A combination for use in a  
2 multi-stage switch, the combination comprising:  
3 a) a plurality of central modules, each including  
4 outgoing links towards output modules including a  
5 plurality of output ports, the output modules  
6 collectively including  $k \times n$  output ports;  
7 b) a plurality of input modules, each including  
8 i)  $k$  groups of  $n$  virtual output queues, and  
9 ii) outgoing links coupled with each of the  
10 plurality of central modules;  
11 c) means for matching a non-empty virtual output  
12 queue of the input module with an outgoing link in the  
13 input module, the means for matching a non-empty  
14 virtual output queue of the input module with an  
15 outgoing link in the input module including  
16 i) master arbiters, each of the master arbiters  
17 being associated with one of the outgoing links,  
18 for selecting a group of virtual output queues  
19 from among those associated with a received  
20 request,  
21 ii) groups of slave arbiters, each group of  
22 slave arbiters being associated with one of the  $k$   
23 groups of  $n$  virtual output queues, for selecting  
24 a virtual output queue from among those  
25 submitting a request, and



26           iii) virtual output queue arbiters, each virtual  
27           output queue arbiter being associated with one of  
28           the virtual output queues, for selecting an  
29           outgoing link from among those submitting a  
30           grant; and  
31        d) means for matching the outgoing link of the input  
32        module with an outgoing link of one of the central  
33        modules.

1   Claim 17 (original): The combination of claim 16 wherein  
2   the means for matching a non-empty virtual output queue of  
3   an input module with an outgoing link in the input module  
4   further include:  
5           iv) means for sending, on behalf of each  
6           non-empty virtual output queue, a request to  
7           slave arbiters, each of the slave arbiters being  
8           associated with one of the outgoing links of the  
9           input module, and each of the slave arbiters  
10          being associated with one of the groups of  
11          virtual output queues; and  
12          v) means for sending, on behalf of each of the  
13          groups of virtual output queues to which a  
14          non-empty virtual output queue belongs, a request  
15          to master arbiters, each of the master arbiters  
16          being associated with one of the outgoing links  
17          of the input module.

1   Claim 18 (original): The combination of claim 16 wherein  
2   the means for matching a non-empty virtual output queue of  
3   an input module with an outgoing link in the input module  
4   performs the match within one cell time slot.

1 Claim 19 (original): The combination of claim 16 wherein  
2 each of the master arbiters operates in accordance with a  
3 round robin discipline.

1 Claim 20 (original): The combination of claim 19 wherein  
2 each of the master arbiters operates independent of the  
3 others.

1 Claim 21 (original): The combination of claim 16 wherein  
2 each of the slave arbiters operates in accordance with a  
3 round robin discipline.

1 Claim 22 (original): The combination of claim 21 wherein  
2 each of the slave arbiters operates independent of the  
3 others.

1 Claim 23 (original): The combination of claim 16 wherein  
2 each of the virtual output queue arbiters operates in  
3 accordance with a round robin discipline.

1 Claim 24 (original): The combination of claim 23 wherein  
2 each of the virtual output queue arbiters operates  
3 independent of the others.

1 Claim 25 (original): The combination of claim 16 wherein  
2 the means for matching a non-empty virtual output queue of  
3 the input module with an outgoing link in the input module  
4 performs multiple matching iterations within one cell time  
5 slot.

1 Claim 26 (original): The combination of claim 16 wherein  
2 the means for matching the outgoing link with an outgoing  
3 link of one of the central modules include:  
4 i) means for sending a request for the outgoing link of  
5 the input module to an arbiter for each of the outgoing  
6 links of the central modules that leads towards an output  
7 port associated with the virtual output queue matched  
8 with the outgoing link of the input module; and  
9 ii) for each of the outgoing links of the central  
10 module, an arbiter for selecting an outgoing link of the  
11 input module from among those that sent a request.

1 Claim 27 (original): The combination of claim 16 wherein  
2 there are:  
3 k input modules, each having n input ports, k  
4 groups of n virtual output queues, and m outgoing links.

1 Claim 28 (original): An input module for use a multi-stage  
2 switch including a plurality of central modules, the input  
3 module comprising:  
4 a) k groups of n virtual output queues;  
5 b) outgoing links coupled with each of the plurality  
6 of central modules; and  
7 c) means for matching a non-empty virtual output  
8 queue of the input module with an outgoing link in the  
9 input module, the means for matching a non-empty  
10 virtual output queue of the input module with an  
11 outgoing link in the input module including  
12 i) master arbiters, each of the master arbiters  
13 being associated with one of the outgoing links,

14           for selecting a group of virtual output queues  
15           from among those submitting a request,  
16           ii) groups of slave arbiters, each group of  
17           slave arbiters being associated with one of the k  
18           groups of n virtual output queues, for selecting  
19           a virtual output queue from among those  
20           submitting a request, and  
21       iii) virtual output queue arbiters, each virtual output  
22       queue arbiter being associated with one of the virtual  
23       output queues, for selecting an outgoing link from among  
24       those associated with a received grant.

1   Claim 29 (original): The input module of claim 28 wherein  
2   the means for matching a non-empty virtual output queue of  
3   an input module with an outgoing link in the input module  
4   performs such matching within one cell time slot.

1   Claim 30 (original): The input module of claim 28 wherein  
2   each of the master arbiters is updated in accordance with a  
3   round robin discipline.

1   Claim 31 (original): The input module of claim 30 wherein  
2   each of the master arbiters operates independent of the  
3   others.

1   Claim 32 (original): The input module of claim 28 wherein  
2   each of the slave arbiters is updated in accordance with a  
3   round robin discipline.

1 Claim 33 (original): The input module of claim 32 wherein  
2 each of the slave arbiters operates independent of the  
3 others.

1 Claim 34 (original): The input module of claim 28 wherein  
2 each of the virtual output queue arbiters is updated in  
3 accordance with a round robin discipline.

1 Claim 35 (original): The input module of claim 34 wherein  
2 each of the virtual output queue arbiters operates  
3 independent of the others.

1 Claim 36 (original): The input module of claim 28 wherein  
2 means for matching a non-empty virtual output queue of an  
3 input module with an outgoing link in the input module  
4 repeats such matching within one cell time slot.

1 Claim 37 (original): The input module of claim 28 wherein  
2 there are  $k$  input modules, each having  $n$  input ports, and  $m$   
3 outgoing links.

Claim 38 (canceled)